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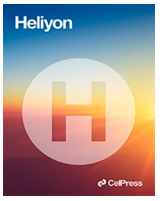

Research article

Income inequality effect of government investment behavior: Comparisons based on different investment areas, different regions and different groups in China

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ABSTRACT

The research focuses on and analyses the effect of government investment on income distribution by evaluating the effects of public spending on income variation in various fields, in various regions, and at different income levels in the Chinese economy. The study found that government investment in different fields substantially decreases income inequality. Increasing housing security, medical, agriculture, forestry and other expenditures has a significant impact on improving the income inequality between rural and urban inhabitants; the impact of government investment in the western, central, and eastern regions on the reduction of income variation is decreasing successively, with emphasis on government investment in the western and central regions. The effects of government investment on the decline of the income distribution are twofold: first, it influences the amount of low- and middle-income groups; second, it has an impact on the reduction of high-income organizations; however, the impact on the income equality of high-income and low-income organizations is not considerable. In investment, the study demonstrates that income inequality can be reduced without negatively affecting the financial status of higher-income individuals. It is significant to value providing adequate housing security for low-income populations as a critical policy implication. This study, utilizing novel indicators, contributes to the current body of research on the impact of fiscal policy in addressing income inequality in China.

1. Introduction

Government investment is vital for the country to accomplish macro-control, promote economic growth, and enhance people's livelihoods. It also has a positive impact on improving income inequality among regions. As government expenditure rises, some academics predict that the influence of government investment on economic development will likewise decrease as a result of the rise in spending [1]. There may be a tipping point (threshold) at which government investment starts to have a detrimental impact on economic growth [2]. Public investment—short-term or long-term—will boost private investment and reduce unemployment,

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particularly in nations with lax economic and monetary policies. However, public investment will increase production more efficiently in nations where government investment funds are funded by bonds and private investment is concentrated in a few significant businesses [3]. Investments in urban regions and workers with greater levels of education yield a low return.

In contrast, those in rural areas and those with lower levels of education yield a better return [4]. The income disparity between urban and rural regions is greatly influenced by government investment. This inequality not only impacts people's lives but also presents significant economic and social challenges, especially in developing countries experiencing fast industrialization and urbanization [5,6].

For the regional economy to grow sustainably, urban and rural areas must work together. One way to gauge a country or region's overall economic development potential is to examine the disparity between urban and rural income levels. Economic and social growth may suffer as a result of a significant urban-rural income disparity. The rural-urban revenue gap accounts for around 40% of the national income disparity. To achieve sustainable development, cities and villages must overcome the rising rural-urban income gap, which has become a significant economic risk and social burden for emerging countries throughout industrialization and urbanization [5]. As a result, it is of great practical and theoretical importance to discuss the spatial outlines and their impact on the essentials of peoples' incomes. They examine their changes and the rural-urban economic disparity and fluctuations, reveal their deep-rooted driving structure, and then put out specific policy recommendations for minimizing the rural-urban income gap and achieving cohesive rural-urban growth [6].

Chinese rural-urban income disparity remains one of the widest in the world, and it is typical of the rest of the globe. China's experience will serve as a model for other nations and areas around the globe trying to address the issue of citizens' income growth and the rural-urban income disparity. Economic growth and social progress in China have increased since its restructuring and beginning, leading to a substantial rise in the incomes of both urban and rural populations [7]. Despite the "miracle of progress," the rural-urban income gap is widening and growing at an erratic pace. The rural-to-urban income disparity in China peaked at 3.33 in 2009 and, despite a reduction, remained at a high of 2.64 in 2019. Urban-rural income disparity in China was less than $209 in the early 1990s, but it increased to $3818 in 2019. The National Bureau of Statistics of China reported an inflation rate of 10% during the same period. A key aspect of addressing the issue of "unbalanced development" will be to shrink further the income disparity between urban and rural communities as Chinese socialism enters a new age. Since poverty eradication and high-quality development in China are becoming more complex, China's governments, scholars, and the public are all concerned about reducing the urban-rural income gap by developing scientific policies that can be implemented in the public sector. According to China's 13th and 14th five-year plans (2011–2020), the rural-urban income gap is a top priority for both the central and local governments. As stated in Judgements of the Central Agency of the State Council and Chinese Communist Party on Broadly Encouraging Rural Revival and Hastening Agronomy and Rural Areas' Modernization in 2021, the central government requires "fully stimulating the development vitality of the countryside to consolidate and expand the results of poverty eradication and continue to narrow the income gap between urban and rural areas". The rural-urban income gap is significantly extensive, serving as an important example for other countries grappling with similar challenges. Despite the notable progress in the economy and society, there has been a concerning rise in income inequality, which calls for immediate policy actions [8–10]. Studied the income inequality between rural and urban areas, using a range of methodologies such as time-series analysis and regression models. However, many of these studies overlook the intricate nature of this issue, frequently disregarding variations in space and other multidimensional factors.

Moreover, many past studies have tried to highlight these issues and minimize this gap, but they have not reached a single opinion. For example, the time series method was used by García-Peñalosa and Turnovsky [8] to examine India's subtleties and arrangements of rural-urban revenue inequality. Rural-urban income inequality in Nigeria has been studied extensively using regression methods by Mierau and Turnovsky [9]. He concluded that factors such as nonfarm enterprises, paid work, grants, and official letters of recommendation have a record influence on narrowing the rural-urban income divide. He further recommended speeding up rural infrastructure development, implementing birth control, and expanding rural access to formal education. As Lim and McNelis [11] found through their research, economic progress and financial development diminish poverty in South Asian nations, while the rural-urban income gap worsens poverty. Using econometric approaches, Galor [10] examined the salary disparity between rural and urban people in Russia's industrialization process. In the Bureau of Research Information Control System countries, Li and Luo [12] used least squares and cointegration tests to observe the association between infrastructure development and rural-urban income disparity. Based on environmental research, relationship analysis, and compound linear regression, Canova [13] found that the health state of the population is a function of absolute income rather than relative wealth. Economic growth and financial development in SAARC countries were examined using the Granger Causality analysis method [14]. The urban-rural income gap and its changes vary significantly across cities. These variations reflect the region's spatial heterogeneity due to economic, social, political, and ecological effects. However, the impact of spatial heterogeneity on the rural-urban income gap and its variations as a result of the methods described above is often challenging to explain. In addition, prior articles fail to consider the geographical effect since they lack practical explanatory and presenting capacity.

The objectives of this examination are to:

- Consider the effects of government investment on income inequality in multiple sectors, regions, and income groups within China.
- Evaluate the effectiveness of different funding methods in carrying out public investment.
- Discover the crucial factors that contribute to the increasing disparity in income in China.

Furthermore, existing research methodologies do not adequately examine the impact of many independent variables on numerous independent and dependent variables. Most of the present publications are practical research on a specific indicator that shows or

drives the rural-urban income gap. However, it is often unreasonable for a single pointer to fully portray the true magnitude of the rural-urban income difference and the difficulty of its forceful processes. China's rising rail construction has narrowed the gap between urban and rural incomes. Despite this, Li [15] found that the convergence effect on income inequality among urban and rural zones in China remains limited. Urban-biased land development policy is the most crucial driver of China's urban-rural income difference, according to Calderón and Servén [16]. As financial development occurs in East China, the urban-rural income disparity widens before narrowing again, according to the findings of López [17]. According to Artadi and Sala-i-Martin [18], the urban-rural income gap in Tunisia is impacted by factors like academic achievement and household size. However, Chen et al. [19] found that family size and educational achievement were the most significant contributors. An analysis of the dynamic association between income patterns and the rural-urban income gap and its running system by Young [20] found that wages are the strong driving force, followed by transfer income, with property income in last place. Researchers in China, including [21–23] found that urban-rural inequality is worse in regions with complicated freight product/target arrangements due to the attentiveness of export undertakings in urban areas and some obstacles that impede the movement of input aspects (like labor and capital) between urban and rural areas, according to their findings. FDI, according to Zhang et al. [24], can help reduce the gap between rural and urban incomes by creating jobs, spreading knowledge, and contributing to economic growth. Still, the research also shows that it can exacerbate the gap between urban and rural incomes through global business and other channels. Several factors influence the urban-rural income gap and its variations, and these factors interact in a complicated way. Deformation or denaturation of the driving force occurs as a result of the driving force being deformed or denaturated by the combined influence of various variables. On the other hand, the existing papers pay little attention to quantitative measurement or in-depth analysis. A lengthy background and rural-urban income gap encourage researchers to investigate and suggest suitable policies to overcome such issues across the economies.

The primary goal of this study is to evaluate the effects of government investment on income inequality between rural and urban areas in China. The study will specifically look at various sectors, regions, and income groups. This study seeks to address the research gap by conducting a thorough and detailed analysis of the impact of government investment on income disparities. By considering the government's influence on investment strategies and the importance of reducing income disparities for sustainable development, this paper is both timely and crucial in guiding future policy decisions. There may be common thinking among readers that China's government has taken initiatives to overcome the problem of urban-rural inequality in China. Therefore, this section also has made an effort to discuss such issues before moving forward to empirical estimations. There has been a number of productive research on the urban-rural income disparity in China. Mainly, research focuses on the urban-rural income gap, its origins and assessment, and how it might be narrowed or eliminated. The Chinese government has introduced different mechanisms, and studies have investigated their impact on rural-urban inequalities. Kibriya et al. [25] used panel data from Wuling Mountain District's 71 counties from 2000 to 2012 to empirically analyze the urbanization process, financial development, and financial expenditure concerning the urban-rural income disparity. The urban-rural income divide is narrowing due to a variety of other variables. China's 1997–2014 provincial panel data were used by Oyekale [26] to build a nonlinear panel threshold model based on Hansen's panel threshold model, which was then applied to the investigation of the urban-rural income disparity. Sehrawat and Giri [27] analyzed data from 262 prefecture-level cities in China between 2000 and 2016 to examine how the urban-rural income difference has changed over time and how it has influenced population movement and household registration. According to Borodkin et al. [28], they constructed a convergence model between government investment and the urban-rural income gap using panel data from 1999 to 2017. According to a study, a converging government investment structure supports the convergence of urban and rural income inequalities. Preventing government investment from increasing too quickly can help narrow the income disparity between urban and rural areas. Vafaei et al. [29] examined the dynamic growth of China's urbanization and the urban-rural income disparity between 2000 and 2016 using panel data from 30 provinces other than Tibet. The consequences of new urbanization on China's urban-rural income disparity are also examined in this paper. The research examines whether the transition of urbanization may narrow China's urban-rural income disparity. Some academics also do research on income club convergence outside of China.

Two-step methods and an ordered logit model were employed by Sehrawat and Giri [30] in their analysis of the convergence trends in per capita incomes of European areas. European areas have been shown to constitute six distinct groups, each with its steady-state trajectory. Human capital and per capita income critically influence whether or not European areas form convergence clubs. Convergence clubs in OECD nations have been identified by Li et al. [31] using a predictive density technique. In 2007, Galor used the Unified Growth Theory to explain the rise of convergence clubs. Urbanization, migration, regional economic growth, and human capital are all variables that contribute to the convergence of the urban-rural income gap, according to the majority of researchers. In China, a widening income disparity between urban and rural areas could benefit from the findings of this research. "With the developing discrepancy between urban and rural incomes in China and the different viewpoints in previous studies, our research seeks to offer a thorough and evidence-based analysis of this matter". We aim to address conflicting findings from previous studies by utilizing proficient empirical models that consider various independent factors that influence income inequality.

In short, studies conducted in China have not keenly focused on the income inequality effect of government investment, and no systematic or in-depth research results have been formed. Only some scholars have conducted long-term research and tracking [32]. Given the importance of studying the income inequality effect of government investment behavior, this paper focuses on the impact of government investment in different fields on income inequality, income inequality in different regions, and income inequality in different income groups to make up for the lack of existing domestic research results.

Here is the structure of the rest of the paper: Section 2 provides a detailed analysis of the empirical research using theoretical modeling. Section 3 explores the data and methodology used in the study. The empirical results within the Chinese context are discussed in Section 4. The paper concludes with policy recommendations in Section 5.

2. Literature review

Su et al. [33] demonstrated that income disparity progresses; Batabyal and Beladi [34] have pointed out that government investment will also exacerbate income inequality. The time track of income inequality is more discerning to changes in government financing policies and has the characteristics of cross-option balance. While income inequality may decrease in the short term, it will increase in the long run [35]. A number of academics have looked at income inequality from the standpoint of infrastructure spending. The research shows that the construction of urban road infrastructure negatively correlates with labor income share, which can effectively reduce income inequality, urban road infrastructure and the negative association between labor income share [36]. There is also a strong correlation between investment in public infrastructure and long-term labor share in public infrastructure expenditures; this correlation is more significant than the elasticity of labor productivity to public R&D investment [37]. The influence of income inequality has also been examined by various researchers, including those who have looked at the effects of education, birth rates, trade, and financial development. Capital endowments are more unequally distributed than labor endowments. Structural changes such as reducing leisure time may increase the labor supply and capital's return rate while decreasing the labor rate [38]. This may lead to an increase in income inequality. Income inequality will rise little as the birth rate rises, and income inequality will rise substantially as the death rate falls. Still, the shifting demographics have an offsetting influence on wealth inequality, causing it to rise and fall above and below average levels.

A rise in marginal productivity and redistributive effects, as well as an increase in income equality, should be expected as trade and financial liberalization progress [39]. This problem of increasing wealth disparity has become increasingly prominent in recent years as China's economy has grown. It has drawn attention from all sectors, including the government and the business community. According to some academics, Chinese residents' income inequality has reached a dangerous level, and this disparity has been overestimated. China's personal income tax distribution effect was amplified between 1997 and 2005, when the tax structure remained constant, and the average effective tax rate was raised. However, the average effective tax rate was cut from 2006 to 2011, worsening the personal income tax distribution effect [40]. However, rising public health spending has benefited low-income populations the most. The rising cost of medical services has countered this benefit and, in some cases, widened the gap between rich and poor. As a result of the government's policy of emphasizing the growth of capital-intensive sectors, demand for urban employment has decreased over time [41]. It is not conducive to increasing the movement of rural labor to the metropolis, further stifling urbanization. The income gap between urban and rural communities is widening as farmers' incomes stagnate and rural land returns shrink [42].

At the same time, judging from the existing literature, the impact of government investment on income inequality is also reflected in two different aspects. On the one hand, government departments have greatly improved public services such as transportation, water conservancy, education, health care and public culture in rural and underdeveloped areas and have provided significant support and guarantee for the welfare improvement and income increase of low-income groups, effectively alleviating the regional gap, urban-rural gap and income distribution gap by investing financial investment funds into infrastructure, education, health care, cultural services, and other public service fields in rural and underdeveloped areas.

For example, Canova [13] empirically explored the influence of framework construction on economic development and revenue delivery. They believed that the provision of infrastructure services such as electricity, water conservancy, and communications in rural areas shortened the time for poor groups to participate in market development, promoted information flow and labor mobility, further promoted the improvement of the non-agricultural economy and increased farmers' incomes, and reduced the incidence of poverty; In addition, the increase in public investment in rural transportation infrastructure in emerging market countries such as India and China will help endorse the rapid development of rural society and economy. It will be accompanied by an increase in investment in public education, science and technology, which will help to reduce the poverty rate and inequality. Galor [10] also researched and believed that improving education and infrastructure in poor areas would help promote financial growth and improve income distribution in poor areas. Thus, government investment played an essential role in encouraging economic progress and improving income disparity.

Moreover, government investment may also exacerbate income inequality. In the process of economic growth, government investment funds interact with labor, private capital and other factors to promote sustained economic growth. The increase in government investment will help promote the increase of private capital-labor productivity, further stimulate the increase of private capital and promote the accumulation of inequality, which will exacerbate the inequality of income or wealth. Elhiraika [43] conducted an in-depth study on Africa's poor economic development and social factors behind it in the 20th century and considered that high commodity prices, low levels of education, raging diseases, unfavorable geographic location, low economic openness, excessive public spending, and military conflicts are essential factors for poor economic performance, Among which, the ratio between private investment and government investment is meager. Government investment accounts for a large proportion. However, due to the low efficiency and irrational investment direction of government investment, economic expansion is weak, and the wealthy also stand to gain more. As a result, it continues to widen between the poor and the rich, and the poor are poorer than the rich. Liu [44,45] combined the CHIP survey data of urban and rural households and used the Oaxaca-Blinder decomposition method to conduct empirical research on the relationship between government education investment, human capital investment and urban-rural income gap. According to the research, the education investment is partial to cities is an essential factor leading to the expansion of the urban-rural income gap in China, with the contribution rate reaching 43.92%. The contribution rate of the education level difference reaching 34.69%, indicating that the education investment level gap is a meaningful determinant of the rural-urban income gap in China.

On urban and rural growth, there are a variety of economic viewpoints to consider. The number of regions (cities) as well as regional economic activity (regional labor markets) is modeled at a macro level. There are two economic sectors, one with constant returns to scale and the other with increasing returns to scale in the industry Li [46]. Technology, factor endowments and information

distribution all contribute to the clustering of companies and production doings in the industrial subdivision. Growth rates are anticipated to be higher in regions with agglomerated production activity because of increased returns to scale and optimistic response processes [36].

Du et al. [47] have investigated the consequences of rural growth in the comprehensive spatial economics of the new economic geography (NEG). The NEG has the potential to make a significant contribution to our understanding of how the economics of industrial organization, conveyance charges, and the present spatial distribution of suppliers and markets affect rural labor market conditions. In most situations, workers' wages in the core area will be higher as of the scale outcome in manufacturing businesses, which will draw more workers from rural areas. It's not always the case that the income gap between rural and urban zones grows or remains.

The majority of private possession of assets and the movement of input variables (labor, capital, and land) are necessary for "clusters" to develop in a market economy. Market prices of input factors will impact enterprises' placement and workforces, resulting in clusters of businesses and metropolitan areas. As a result, industry and urbanization are closely connected [44,45].

Although these main prerequisites are not met in China, as a consequence, industrial groups in China have emerged under various institutions and methods. It wasn't until 2004 that the private sector was officially acknowledged by the constitution, notwithstanding the fast development of the de facto private sector since 1997, when state-owned firms were in grave crisis [3]. Government control of all input parameters restricted entrepreneurial enterprises' ability to choose where to locate at the beginning of reform. Rural land's free trade limitation is the most severe constraint on the market. To date, farmers have not been able to sell their land for non-agricultural reasons, individually or collectively. The Hukou (residence registration system) is linked to government control of land and inhibits peasant labor mobility, notably from rural to urban regions [2]. When accessing local social welfare benefits, people who work outside of their Hukou's geographic area are not eligible or discriminated against. Despite the Hukou system being relaxed over time, people who work outside of their Hukou's geographic area are not eligible or discriminated against [1]. Small and medium-sized businesses in rural areas are also hampered in their ability to get formal financial resources [4].

During the post-Mao era, rural China has seen enormous progress, and absolute poverty has decreased significantly. There was a dramatic growth in rural dwellers' per-capita disposable income from 134 to 16,021 RMB between 1978 and 2019. Despite the government's efforts, poverty persists in many rural areas of China, leaving many inhabitants behind [5].

Rural China has been the subject of numerous research attempts to uncover the variables contributing to poverty and income inequality. According to Zhang et al. [6], the spatial poverty trap in rural China may have been exacerbated by public goods and services supplied by the government and private investment. Xu et al. [14] find that rural poverty in China is primarily due to a lack of access to domestic and foreign markets. The Hukou system has been cited as a significant determinant of rural incomes in various research [12]. From a political economy viewpoint, Lim and McNelis [11] found that the human resource of native management has a significant influence on rural populations' earnings, while Calderón and Servén [16] found that village election and anticipated land tenure influence the relocation results of rural populations and therefore their income. Similar findings have been made by López [17], who found that rural inhabitants' low income is due to resource misallocation. Further research suggests that the reduction in agricultural prices and an increase in nonfarm activities like migration contribute to the income disparity in rural China due to the collapse in farm revenues.

A new study adds to the body of knowledge on rural China's income growth and distribution patterns by identifying the specific mechanisms that cause these disparities. According to our hypothesis, the rise and growth of industrial groups in China as a reaction to organized restraints has distinct effects on rural income distribution. There is less resistance to entrepreneurship in clusters because of their high degree of specialization. The familiar teamwork of all important participants inside the cluster means there is no need for integration. Rural communities benefit from equal access to business and job possibilities in their homelands because of inclusive clusters like these. Local entrepreneurs and employment prospects can benefit not only native leaders but even the most vulnerable rural populations. Some of the most disadvantaged populations cannot leave their communities to work in other places and end up in absolute poverty because they lack the means. Because there are more chances for nonfarm activities in rural areas where industrial groups exist, we expect to see a rise in nonfarm income and a decrease in income inequality among rural households.

3. Methods and data

3.1. Model construction and index selection

In order to further analyze the income inequality effect of government investment behavior, the following empirical regression model is established in Eq. (1):

$$Inequal_{it} = \alpha_0 + \alpha_1 Gov\_inv_{it} + \sum_{n=2}^{M} \alpha_n X_{it} + \varphi_i + \omega_t + \varepsilon_{it} \tag{1}$$

where $Inequal_{it}$ represents the explained variable and refers to the income inequality of region i in year t. Referring to the relevant practices of Yang and Sun [48] and Zheng et al. [49], the ratio of per capita disposable income of urban populations to per capita net income of rural populations is applied to represent the income inequality index of various regions. Gov_inv_{it} It is the explanatory variable, which represents the government investment indicator of region I in year t, and the government investment indicator is represented by the logarithm of the state budget funds in the funds invested in the fixed asset investment of the whole society. More specifically this variable is transformed using logarithms and represents the amount of state budget funds allocated to investments in

fixed assets within society as a whole. X_{it} It is a control variable, including financial development, tax burden level, unemployment rate, and education level. Among them, financial development indicators are expressed by the ratio of the balance of deposits and loans of financial organizations to the GDP at the end of the period; the level of the tax burden is stated as the ratio of tax revenue to the gross regional product; the unemployment rate is expressed by the unemployment rate of registered urban unemployed in different regions; education is stated in terms of the part of the population with a college degree or above. φ_i, ω_t Denote the fixed effects in region i and year t, respectively. ε_{it} Represents the error term.

3.2. Data source and statistical description

In terms of data sources, the indicator data mostly comes from the "China Statistical Yearbook" from 2006 to 2017 and the local government's nationwide social and economic development statistical bulletin. At the same time, the raw data of per capita disposable income of urban populations and per capita, net income of rural populations of low-income groups, low-middle-income groups, middle-income groups, middle-high-income groups, and high-income groups are mainly derived from the data on the net income of rural populations and the disposable income of urban populations in the five equal income groups in the statistical yearbooks of each region (for the seven equal grade income data and the ninth-grade equal income data, The data used in this analysis are obtained from the statistical yearbooks of different regions. To ensure comparability, the data is normalized based on population proportions. This normalization is particularly important when examining income datasets for different education levels. In order to address the impact of price factors, such as inflation, adjustments are made to government investments and other indicator data. These adjustments are based on the inflation rate of the previous year, which is set at a base of 100. The statistical characteristics of the above variables are described in Table 1.

4. Results and discussion

4.1. Impact of government investment on income inequality in different areas

Because government investment involves different fields, according to the characteristics of government investment behavior, this paper selects ten types of local government expenditure, such as education spending, science and technology spending, sports, cultural and media spending, employment and public security spending, health care and family planning expenditure, energy protection and ecological protection spending, urban maintenance spending, agro-for-forest water expenditure, transportation expenditure, housing security expenditure to study the impact of government investment on income inequality in different fields. Regression results are shown in Tables 2–3. It can be seen that government investment in diverse areas has a significant influence on dropping income inequality. Still, there are significant variances in the influence of government investment on income inequality in different fields. From the point of view of the regression coefficient of government investment indicators, cultural sports and media spending and housing security spending have the most significant impact on reducing income inequality, and their effect on improving income inequality among residents is most significant, which shows that cultural sports and media expenditure has a significant influence on improving and enriching the ideological and cultural situation of urban and rural residents, and then taking practical actions to improve their living conditions, while housing security expenditure has a direct influence on improving the living conditions of low-income groups; Secondly, health care and family planning expenditure, agriculture, for forest and water expenditure, energy

Table 1
Variable statistical characterization.

Variable	Description	Unit	Average value	Standard deviation	Min	Max	Notes on Outliers
GDP per capita	Gross Domestic Product per individual	USD	2.8938	0.5534	1.8451	4.5936	–
Inflation rate	Annual percentage change in consumer price index	%	1.3299	0.9496	−1.4987	3.0715	–
Unemployment rate	Percentage of the labor force that is jobless and seeking employment	%	1.1545	0.4282	0.5455	2.6453	High outliers in some regions
Crime rate	Number of reported crimes per 100,000 population	cases/ 100 k	0.0777	0.03	0.0304	0.1997	–
Income inequality (Gini Index)	Measure of income distribution across income percentiles	Index (0–1)	0.0351	0.0065	0.012	0.051	–
Income inequality among low-income groups	Measure of income distribution among the lowest 20% of income earners	Index (0–1)	0.1052	0.0663	0	0.4546	High std. dev. indicates potential outliers
Income inequality among high-income groups	Measure of income distribution among the highest 20% of income earners	Index (0–1)	4.9796	3.8815	0.2056	23.2077	–
Government investment in education	Percentage of GDP allocated to education	%	0.6493	0.8662	0.009	7.4371	–
Government investment in healthcare	Percentage of GDP allocated to healthcare	%	0.5648	0.4157	0.0401	2.2994	–

Table 2
Regression results of the impact of government investment in different fields on income inequality.

Name of Variate	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Type of Model	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
Indicator of government investment	−.0344*** (1%)	−.0347*** (1%)	−.03438*** (1%)	−.03472*** (1%)	−.1449** (5%)	−.1706*** (1%)	−.0467*** (1%)	−.0486*** (1%)	−.0784*** (1%)	−.0775*** (1%)
Financial development	−.2466*** (1%)	−.2123*** (1%)	−.2466*** (1%)	−.2123*** (1%)	−.2602*** (1%)	−.2151*** (1%)	−.2203*** (1%)	−.1843*** (1%)	−.2170*** (1%)	−.1867*** (1%)
Rate of unemployment	22.8420*** (1%)	20.5026*** (1%)	22.8420*** (1%)	20.5026*** (1%)	24.4947*** (1%)	22.2857*** (1%)	23.6394*** (1%)	21.6852*** (1%)	23.3064*** (1%)	21.1434*** (1%)
Level of education	−1.1698** (5%)	−1.5120*** (1%)	−1.1698** (5%)	−1.5120*** (1%)	−2.3443*** (1%)	−2.4084*** (1%)	−1.2314** (5%)	−1.4780** (5%)	−0.8518	−1.2625** (5%)
Constant term	2.6722*** (1%)	2.7522*** (1%)	2.6722*** (1%)	2.7522*** (1%)	2.6641*** (1%)	2.7108*** (1%)	2.6141*** (1%)	2.6740*** (1%)	2.5801*** (1%)	2.6621*** (1%)
FE of year	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
FE of region	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
F-value	112.30	–	112.30	–	94.17	–	105.93	–	123.02	–
Wald chi2	–	426.51	–	426.51	–	353.32	–	408.31	–	466.68
R-sq_within	0.5948	0.5934	0.5948	0.5934	0.5518	0.5502	0.5807	0.5794	0.6166	0.6152

Note: The fitting factors are significant at 1%, 5% and 10%, respectively. The parameters in parentheses are the corresponding t-value or z-value.

Table 3
Regression results of the impact of government investment in different fields on income inequality.

	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20
Type of Model	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
Indicator of government investment	−0.007	−0.0861** (5%)	−0.0133	−0.0194** (5%)	−0.0601*** (1%)	−0.0588*** (1%)	−0.0535*** (1%)	−0.0536*** (1%)	−0.0999*** (1%)	−0.1041*** (1%)
Financial development	−0.2444*** (1%)	−0.2035*** (1%)	−0.2706*** (1%)	−0.2202*** (1%)	−0.1814*** (1%)	−0.1542** (5%)	−0.2369*** (1%)	−0.1985*** (1%)	−0.2383*** (1%)	−0.1869*** (1%)
Rate of unemployment	29.8454*** (1%)	26.9797*** (1%)	25.7893*** (1%)	23.9009*** (1%)	22.5803*** (1%)	20.5334*** (1%)	23.2449*** (1%)	21.3374*** (1%)	24.1734*** (1%)	18.7955*** (1%)
Level of education	−2.5076*** (1%)	−2.5506*** (1%)	−2.6571*** (1%)	−2.5559*** (1%)	−0.9234	−1.3720** (5%)	−1.7403*** (1%)	−2.0569*** (1%)	−0.12298	−1.5472*** (1%)
Constant term	2.4534*** (1%)	2.5240*** (1%)	2.6188*** (1%)	2.6329*** (1%)	2.5931*** (1%)	2.6768*** (1%)	2.6363*** (1%)	2.6923*** (1%)	2.5217*** (1%)	2.6827*** (1%)
FE of year	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
FE of region	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
F-value	87.33	–	92.58	–	114.12	–	110.89	–	36.78	–
Wald chi2	–	320.09	–	342.84	–	437.42	–	417.30	–	123.89
R-sq_within	0.5595	0.5577	0.5475	0.5452	0.5987	0.5973	0.5918	0.5905	0.4470	0.4410

Note: The fitting factors are significant at 1%, 5% and 10%, respectively. The parameters in parentheses are the corresponding t-value or z-value.

conservation and environmental protection expenditure, its impact on reducing income inequality is relatively significant, but the influence of environmental protection and energy conservation expenditure on reducing income inequality is relatively weak, in particular, we can see that family planning and health care spending and agriculture, for forest and water spending on low-income groups have a significant impact, so they are the people's livelihood expenditure; the third is transportation spending, social security and employment expenditure, education spending and science and technology spending, all of which have a greater impact on reducing income inequality, and are significant at the 1% level, denoting that the improvement of transportation conditions, the increase of social security expenditure, the increase of employment, the increase of education expenditure and the increase of scientific and technological development all have a significant influence on the improvement of regional income inequality. The impact of urban maintenance expenses on decreasing income inequality is relatively minimal. At the same time, it can be seen that financial development and higher levels of education have a significant influence on reducing income inequality. In contrast, unemployment has a significant influence on increasing the income disparity.

4.2. Impact of government investment on income inequality in different regions

In order to further explore the influence of government investment on income disparity in different regions, this paper divides the country into three areas: the eastern regions, including Beijing, Tianjin, Hebei, Shandong, Shanghai, Guangdong, Jiangsu, Zhejiang, Liaoning, Fujian, and Hainan, the central regions including Shanxi, Jilin, Heilongjiang, Jiangxi, Anhui, Henan, Hunan, Hubei, and the western regions, including Chongqing Guangxi, Sichuan, and Yunnan Ningxia, Xinjiang and Tibet. To this end, the data of each indicator is divided into three regional samples for research. Then, the regression results of the impact of government investment on income inequality in different regions are obtained (as shown in Table 4). It can be seen that government investment in the eastern, central and western areas has a meaningful influence on income inequality in the region, but there are also some differences in the impact of government investment in the central, eastern and western regions on lessening income inequality, with government investment in the western region having the most significant impact on dropping income inequality in the region, and significantly at the 1% significant level; secondly, government investment in the central region is also very significant in dipping income inequality, but also at the 1% significant level; the third is the government investment in the eastern region, which is also more significant in reducing income inequality, but its impact on reducing income inequality is less than that of the western and central regions, that is, the impact of government investment in the eastern, central and western regions on reducing income inequality, from large to small, in order of the western region, the central region and the eastern region, which shows that the impact of government investment in the western region on reducing income inequality is more prominent, and then with the regional characteristics of the central and eastern regions decreasing in turn, the central region's need and desire for government investment to improve income inequality among its residents is more urgent and practical. In addition, the impact of the unemployment rate and education level on income inequality in the western region is significant at the 1% level. The tax burden level, unemployment rate and education level also substantially influence income inequality in the central region, and financial development in the eastern region significantly influences income inequality. Still, the impact of the unemployment rate and education level on income inequality is insignificant. It can also be seen that government investment, financial development and education in the whole country have a significant impact on reducing income inequality. At the

Table 4
Regression results of the impact of government investment on income inequality in different regions.

	Eastern		Central		Western		National	
Name of variate	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	Fixed effect (FE)	Random effect (RE)	Fixed effect (FE)	Random effect (RE)	Fixed effect (FE)	Random effect (RE)	Fixed effect (FE)	Random effect (RE)
Government investment	−0.0611** (−1.98)	−0.0592*** (−2.79)	−0.0811*** (−2.71)	−0.0838*** (−2.63)	−0.1885*** (−4.32)	−0.1843*** (−4.35)	−0.1132*** (−4.30)	−0.1135*** (−4.98)
Financial development	−0.4840*** (−4.12)	−0.4311*** (−4.26)	−0.2112* (−1.71)	−0.0884 (−0.68)	0.1447 (1.55)	0.1130 (1.25)	−0.1518** (−2.26)	−0.1159* (−1.73)
The level of tax burden			−6.8763*** (−3.56)	−5.3788*** (−2.64)	−1.7627 (−0.74)	−2.5204 (−1.11)	−2.0576 (−1.38)	−1.6573 (−1.19)
Unemployment rate	−2.6085 (−0.51)	−6.1043 (−1.35)	18.5983*** (4.20)	16.4625*** (3.49)	32.2032*** (3.34)	25.2755*** (2.84)	19.4265*** (4.24)	18.3285*** (4.15)
Educational rate	0.3855 (0.52)	0.07401 (0.13)	−2.2621** (−2.32)	−3.3789*** (−3.30)	−3.6908*** (−3.64)	−4.0507*** (−4.11)	−1.3804** (−2.26)	−1.7856*** (−3.15)
Constant term	3.2625*** (12.42)	3.3474*** (15.05)	2.8996*** (12.80)	2.8828*** (11.44)	2.7306*** (5.29)	3.0997*** (6.45)	2.8440*** (11.19)	2.8529*** (11.69)
Fixed effect of year	Control	Control	Control	Control	Control	Control	Control	Control
Fixed effect of region	Control	Control	Control	Control	Control	Control	Control	Control
F-value	15.89	–	81.32	–	70.47	–	84.07	–
Wald chi2	–	63.35	–	329.10	–	342.85	–	396.39
R-sq_within	0.3749	0.3696	0.8443	0.8403	0.7539	0.7526	0.5795	0.5781

Note: The fitting factors are significant at 1%, 5% and 10%, respectively. The parameters in parentheses are the corresponding t-value or z-value.

Table 5
Regression results of the impact of government investment on income inequality of different income groups.

	Low-income groups		Middle-low income groups		Middle income groups		Middle-high income groups		High-income group	
Name of variate	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
Government investment	0.1229 (0.13)	0.3750 (0.42)	−0.0973* (−1.79)	−0.0828* (−1.69)	−0.1245* (−1.83)	−0.0871* (−1.78)	−0.1751** (-2.15)	−0.1300** (−2.49)	−0.1034 (−1.45)	−0.0895* (−1.88)
Financial development					−0.2553 (−0.93)	−0.2757 (−1.15)	−0.3150 (−1.12)	−0.2247 (−0.93)	−0.9562*** (−3.86)	−0.7302*** (−3.33)
The level of tax burden					0.4212 (0.08)	−3.9946 (−1.15)	0.0030 (0.00)	−1.5386 (−0.39)	3.7682 (0.80)	4.0281 (1.13)
Unemployment rate			22.3640 (1.33)	18.5831 (1.47)	5.8465 (0.34)	−3.2630 (−0.24)	−3.9688 (−0.22)	−7.6267 (−0.59)	14.1958 (0.91)	11.2407 (0.95)
Educational rate							−1.3400 (−0.69)	−2.6738* (−1.71)	2.6354 (1.55)	0.7717 (0.54)
Constant term	4.010 (2.55)	4.4372 (1.93)	2.3302*** (3.88)	2.4821*** (5.27)	3.1494*** (3.45)	3.8318*** (5.75)	3.7408*** (3.99)	3.9837*** (6.32)	2.9765*** (3.62)	2.9232*** (5.06)
FEt of year	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
FE of region	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
F-value	0.02	–	5.89	–	4.91	–	8.19	–	8.73	–
Wald chi2	–	0.18	–	9.03	–	20.62	–	44.83	–	35.76
R-sq_within	0.0001	0.0001	0.0849	0.0849	0.1357	0.1291	0.2483	0.2427	0.2603	0.2500

Note: The fitting factors are significant at 1%, 5% and 10%, respectively. The parameters in parentheses are the corresponding t-value or z-value.

same time, unemployment has a significant impact on widening income inequality.

4.3. The impact of government investment on income inequality of different income groups

In order to further explore the influence of government investment behavior on income inequality of different groups, this paper selects five groups (each accounting for 20% of the population) of urban and rural income data for classification research according to the availability of disposable income or net income data of different groups in the statistical yearbooks of each region and then analyze the impact of government investment behavior on income inequality of different income groups. The regression results are shown in Table 5. It can be seen that government investment has the most significant effect on reducing income inequality of middle and high-income groups, and it passes the significance test at the level of 5%. Secondly, government investment also significantly reduces income inequality of middle-income and low-income groups, all of which pass the significance test at the 10% level. At the same time, Model 9 and Model 10 show the impact of government investment on the income inequality of high-income groups. Hausman's test of the regression results of the fixed-effects model and the random-effects model shows that the chi-square statistic is 18.14 and the corresponding adjoint probability is 0.003, indicating that the coefficients of the random-effects model and the fixed-effects model are systematically different. The fixed-effects model should be selected. Therefore, it can be seen that the impact of government investment on the income inequality of high-income groups is not significant. In addition, it can also be seen that the impact of government investment on the income inequality of low-income groups is not significant, indicating that government investment still has specific problems or limitations in improving the income inequality of low-income groups, and it is urgent to improve the skewed support of government investment for low-income groups.

4.4. Robustness test

To further explore the robustness of the above regression model fitting effect, the following robustness analysis is carried out:

(1) Regarding the impact of government investment in different fields on income inequality, the difference between urban and rural residents per capita disposable income is used to replace the ratio of urban and rural residents' per capita disposable income. The regression results are consistent, indicating that the regression results of the model are robust.
(2) Regarding the impact of government investment behavior on income inequality in different regions and income inequality of different income groups, transportation expenditure indicators are selected to replace government investment indicators. The regression results are consistent, indicating that the regression results of the model are robust.

4.5. D-H panel causality test

According to the given results of the D-H panel causality test in Table 6, the findings show exciting outcomes. They found a bi-directional causality between government investment (GI) and income inequality (II) for all selected income groups except low, middle-income and low-income groups. For such a group, there was an uni-directional causal relationship between income inequality and government investment. Likewise, a two-way causal association was found between financial development and income inequality for the selected income groups, except middle middle-income and high-income groups. Moreover, tax burden (TB) has a bi-directional association with income inequality for the middle-income and high-income groups.

In contrast, the remaining group, low-income and low-middle-income, have uni-directional causality from tax burden to income inequality. Similarly, the unemployment rate (UR) has a bi-directional association with income inequality. Besides, it has an uni-directional association between the unemployment rate and income inequality in Low, Middle-income and Middle-income high-income groups. However, there was a one-way causal association between income inequality and the unemployment rate in the case of the high-income group. In the last, there was a two-way causal association between education rate (ER) and income inequality in middle-income and high-income groups. At the same time, uni-directional causality was found from ER to income inequality in low-

Table 6
Results of Panel Causality test.

	Low Income		Middle Low Income		Middle Income		Middle high income		High Income	
	W-Stat.	Z-Bar	W-Stat.	Z-Bar	W-Stat.	Z-Bar	W-Stat.	Z-Bar	W-Stat.	Z-Bar
GI ≫ II	3.5552*	2.9923	1.5289	0.6966	6.7888*	3.5541	4.5552*	3.2256	3.8563*	1.4563
II ≫ GI	2.0745	1.7856	4.5682*	3.2221	7.8963*	4.5555	5.9685*	3.7855	5.6523*	2.7789
FD ≫ II	4.8541*	3.2214	5.2154*	3.6532	2.3244	1.2287	3.6932*	2.8545	1.5523	0.7589
II ≫ FD	6.9821*	4.7523	7.9865*	4.8754	1.8956	0.4255	4.2224*	3.3354	6.7852*	2.9963
TB ≫ II	4.6698*	3.4555	3.6655*	2.2136	5.8852*	3.2698	1.5741	0.7368	4.5223*	3.5554
II ≫ TB	2.4512	1.3321	2.1028	1.1196	7.2554*	4.1156	2.9965	1.2258	7.9645*	4.1234
UR ≫ II	3.6521*	2.8954	2.9996*	1.2387	4.0589*	3.5641	4.5523*	3.8666	2.5242	1.2389
II ≫ UR	2.2345	1.6598	1.0569*	0.4523	2.2533	1.5541	1.2578	0.4123	4.8887*	2.5693
ER ≫ II	3.5232*	2.2187	5.2398*	3.5463	3.9996*	2.7741	3.5698*	2.5478	5.2365*	3.5698
II ≫ ER	1.8574	0.2296	2.9865	1.4124	5.6335*	3.4529	2.2322	1.8965	7.2289*	6.4569

Note: GI: Government Investment, II: Income Inequality, FD: Financial development, TB: Tax Burden, UR: unemployment rate and ER: education rate.

income, low-middle-income and middle-high-income groups.

5. Conclusions and policy recommendations

In order to deeply study the income inequality effect of government investment behavior, this paper uses fixed effect models and random effect models to focus on and analyze the income inequality effect of government investment from the perspective of the impact of government investment in different areas on income inequality in different regions and the impact of government investment on income inequality of different income groups by using the panel data of 31 provinces (municipalities and autonomous regions) in China from 2006 to 2017. The findings of the study show that government investment in different fields significantly impacts income inequality. Still, there are significant differences in the impact of government investment in different fields on income inequality. Among them, the expenditure on culture, sports and media, and housing security have the most significant impact on reducing income inequality, followed by the expenditure on health care and family planning, agriculture, forestry and water, and the third is the expenditure on transportation, social security, employment, education and science and technology. The research shows that increasing the expenditure of the people, such as housing guarantees, medical care, agriculture, forestry, water conservancy, transportation infrastructure and education, has a significant impact on improving the income inequality of urban and rural residents. Therefore, the government should continue to increase investment in these areas and exert its influence on improving income inequality. At the same time, it is necessary to increase cultural, sports and media expenditures, which will have a positive internal cultural promotion for enriching the spiritual and cultural life of urban and rural residents, improving their happiness in life, and transforming their cultural thoughts to realizing oneself out of poverty and becoming rich.

Moreover, the findings indicate that government investment in the eastern, central and western regions significantly impacts income inequality in the region. However, there is also a certain degree of difference between the eastern central region and the western region in the impact of government investment on narrowing income inequality. The impact of government investment on the narrowing income inequality in the eastern, central, and western regions in descending order is that of the western central and eastern regions. The impact of improving income inequality decreases successively, showing that government investment in the western and central regions in improving resident income inequality is more significant than that in the eastern region. Therefore, the government investment in improving income inequality should focus on the investment in the central and western regions, especially the western regions. Government investment is the most significant in reducing the income inequality of middle and high-income groups, and it has the most significant degree of reducing income inequality in this income group. The second is the impact on reducing income inequality between middle-low income groups and middle-income groups. The impact on both is second only to the impact on middle-high income groups. However, government investment has no significant impact on income inequality among high-income groups and income equality among low-income groups. It indicates that government investment has limited influence on these two groups, especially on low-income groups. It also indicates that government investment still has some limitations or problems in improving income inequality of low-income groups, so it is urgent to improve the support and influence of government investment on low-income groups.

Across the country, government investment, financial development, and education levels significantly reduce income inequality, while the unemployment rate significantly impacts widening income inequality. Among them, the unemployment rate and education level in Western regions have a significant impact on income inequality. The tax burden level, unemployment rate and education level have a significant influence on income inequality in the central region. Financial development in the eastern region significantly impacts income inequality, but the impact of the unemployment rate and education level on income inequality is not significant. Therefore, it can be seen that government investment in different fields has a significant impact on income inequality. Government investment also has a significant impact on income inequality in different regions, and the impact of government investment on different income groups is also different.

The policymakers should concentrate on developing technology policies that are beneficial to the Western region, rural families, and residents with low and middle incomes. The policies should further promote opportunities for all people to enjoy the achievements of the development of financial technology. They should also increase technology innovation services for vulnerable groups such as farmers and families with low incomes. The policymakers are responsible for paying attention to the credit requirements of the vulnerable groups and the quality of the services provided to them. To effectively play the value of fintech innovation, policymakers should simultaneously formulate pertinent policies to improve the construction of fintech infrastructure services in western areas, improve the penetration of fintech innovation services, and improve the convenience of technology innovation services.

More significant investment results can be obtained by increasing government investment in the central and western regions, especially in the western region. At the same time, increasing government investment in the central and western regions, especially in the western region, can achieve more excellent investment results. Moreover, through government investment, income inequality among middle-high-income, middle-low, and middle-income groups can be reduced without affecting the cake distribution of high-income groups. It can reduce the income inequality of other groups while maintaining the income level of high-income groups, further optimize their income distribution share, and reduce the income distribution gap. However, it is still necessary to focus on government investment support for low-income groups, promote targeted poverty alleviation and make sure people are out of poverty, and increase housing security expenditures for low-income groups, medical and health and family planning expenditures, agriculture, forestry and water expenditures, and education expenditures. It will help improve the income inequality of low-income groups and better achieve fairness and justice. It is also an essential original intention of government investment.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Chao Lian: Writing – original draft, Methodology, Formal analysis, Data curation. **Jinping Pei:** Formal analysis, Data curation. **Jiaying Li:** Writing – review and editing, Resources, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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